Journal of the Royal Society of Western Australia, 78:99-101, 1995

Diurnal stratification of Lake Jandabup, a coloured wetland on the Swan Coastal Plain, Western Australia

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Manuscript received June 1995; accepted February 1996

Abstract

Variations in temperature and dissolved oxygen gradients were examined for three microhabitats in Lake Jandabup over a 24 hour period in 1993; each microhabitat was thermally stratified between 1300 and 1900 hrs. The presence of a shallow water column (< 0.5m) that is shown here to stratify thermally under a known set of conditions has implications for sediment nutrient release, insufficient oxygen supply for aerobic organisms and an accumulation of organic sediments.

Introduction

The presence of dissolved humic substances in aquatic systems can influence the physical and chemical characteristics of the standing water (Kuuppo-Leinikki & Salonen 1992), causing the rapid attenuation of solar radiation at shallow depths (Bowling *et al.* 1986) and producing steep thermal gradients that are resistant to mixing (Bowling 1990). Literature regarding the stratification of Australian inland waters is dominated by studies of large and/or deep lakes and reservoirs (*e.g.* Bowling 1990) with Western Australian literature also having these emphases (*e.g.* Imberger 1985). Recent work has highlighted the stratification of coloured or saline waters in southwestern Australia. For instance, Edward *et al.* (1994) found many coastal wetlands in the extreme southwest to be thermally stratified, while Burke & Knott (1989) demonstrated that saline Lake Hayward in Yalgorup National Park was monomictic. Schmidt & Rosich (1993) examined stratification and thermal stabilities of Swan Coastal Plain wetlands, concluding that only deep (>3m) or highly coloured wetlands would stably stratify. However, Burke & Knott (1989) showed that stratification can be achieved in shallow lakes, provided that there was sufficient salinity difference between the upper and lower water layers.

The aim of this study was to examine diurnal fluctuations in temperature and dissolved oxygen gradients over a 24 hour period during autumn in Lake Jandabup.

Methods

Lake Jandabup occupies a shallow (<1.5 m), oval-shaped basin, 22 km north of Perth on the Swan Coastal Plain (Allen 1979). The littoral zone is dominated by *Baumea articulata* (R Br) ST Blake (jointed twig rush) and other rushes with *Typha orientalis* C Presl (bulrush) limited to isolated pockets within the lake (Froend *et al.* 1993).

The study sites 1, 2 and 3 (see Ryder & Horwitz 1995) were within vegetation communities dominated by *B. articulata*, *T. orientalis* and a community with no emergent or submerged vegetation respectively. Dissolved oxygen (DO; % saturation) and temperature (°C) were recorded at two hourly intervals *in situ* on March 20 to 21, 1993, over a 24 hour period using a portable *Wissenshaftlich Technische Werkstätten* Oximeter. Measurements were made at the top (5 cm below water surface) and bottom (epibenthic) of the water column. Ambient air temperature and wind data were obtained from the Bureau of Meteorology.

Results

Water depths at sites 1, 2 and 3 were 0.449 m, 0.404 m and 0.453 m respectively. The maximum air temperature on site was 26.5°C at 1500 hours and the minimum of 13.1°C was recorded at 0500 hours. Wind data are shown in Fig 1.

A thermal gradient was present between the top and bottom of the water column at all sites between 1300 and 1900 hours. Sites 1 (*B. articulata* community), and 2 (*T. orientalis* community) exhibited the greatest differences between surface and epibenthic temperatures, of 6.6°C and 6°C respectively (Fig 1). Site 3 (open water) had the highest surface temperature of 24.1°C; however, only a 3.4°C maximum temperature difference was evident. All sites displayed low epibenthic oxygen saturation while surface water remained well oxygenated. Site 1 had the lowest epibenthic DO level of 0 % saturation. Site 2 displayed similar, although slightly higher values. Site 3, which was exposed to the prevailing winds more so than the other sites, had a surface oxygen level reaching 128 % saturation at 1700 hours, with epibenthic DO levels of 11 % saturation.

Discussion

This study has demonstrated the potential for the daily thermal stratification of Lake Jandabup, despite its shallow water depth and relatively high surface area. The climatic conditions, particularly the wind pattern, were typical of summer and autumn conditions experienced on the Swan Coastal Plain (Gentilli 1972). This

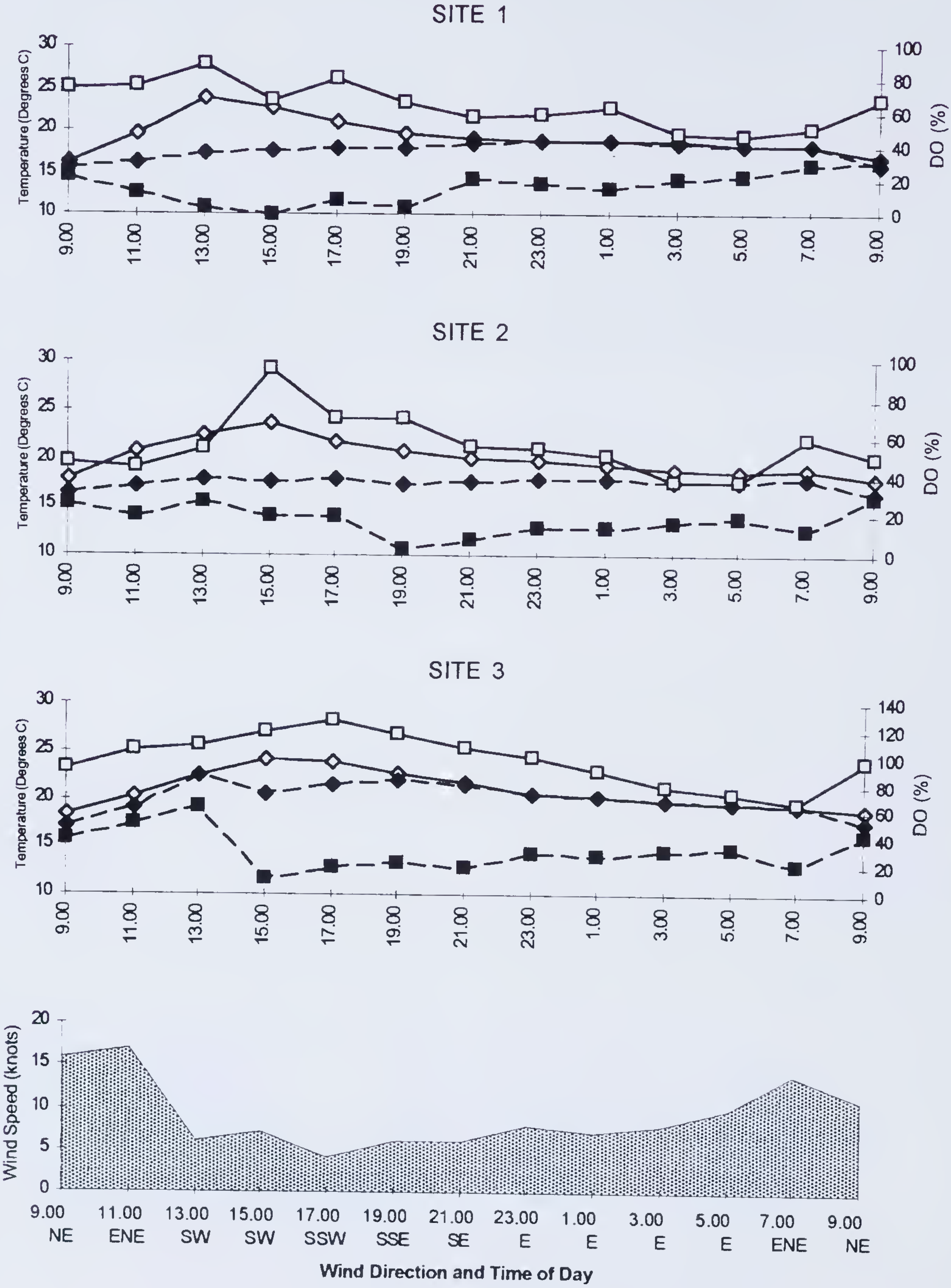

Figure 1. Temperature (°C) and DO saturation (%) readings for the top and bottom of the water column at sites 1, 2 and 3, and windspeed and direction over the 24 hour study period from 20 to 21 March 1993. Temperature top ◇, temperature bottom ◆, DO top □, DO bottom ■.

pattern of daily stratification could therefore be expected to occur regularly over a six month period.

Surface and epibenthic temperature differences and epibenthic deoxygenation were most pronounced in the dense *B. articulata* community and least evident in open water. As the major mixing force in wetlands is produced by the shearing effect of the wind at the water surface (Schmidt & Rosich 1993), it appears that the emergent vegetation may be limiting the input of atmospheric oxygen as well as providing shelter and resistance to mixing. Wetlands such as Lake Jandabup, with large areas of emergent vegetation and coloured water may therefore have an exacerbated daily and seasonal cycle of thermal stratification.

Based on traditional limnology (*e.g.* Wetzel 1983), wetlands such as Lake Jandabup would be classified as warm polymictic, based on the temperature, climate and basin geomorphology. However, despite the obvious shallowness of Lake Jandabup, the presence of a water column that has been shown to stratify thermally under a known set of conditions requires the wetland to be classified as warm continuous monomictic.

The presence of a stratified water column based on thermal profiles is supported by differences in surface and epibenthic DO levels. These DO differences are most pronounced during the period of thermal stratification, but persist throughout the 24 hour period due to the atmospheric diffusion of oxygen through the water column being unable to supply the high oxygen demand of the organic soils present in the lake. This has implications for sediment nutrient release, insufficient oxygen supply for the metabolic requirements of aerobic organisms, and an accumulation of organic sediments in Lake Jandabup and other similar wetlands on the Swan Coastal Plain.

Acknowledgments: We would like to thank Mr Doug Ryder and Mr Allan Ellies for their help in the field.

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